Preliminary observations on termite diversity in native *Banksia* woodland and exotic pine *Pinus pinaster* plantations

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Abstract

Preliminary observations on termite diversity recorded 16 termite species from 10 genera for native *Banksia* woodland at Gnangara on the Swan Coastal Plain and 7 species from 5 genera for adjacent areas of 40 - 70 year-old exotic maritime pine *Pinus pinaster* plantations. Only 3 species were recorded eating pine; the remaining 4 species in pine plantations survived by foraging on remnant stumps, logs and roots of *Eucalyptus* only. We hypothesize that low termite diversity in pine may in part be due to replacement of palatable native woody plants with unpalatable exotic pine and changes in soil microclimatic conditions. Following plantation establishment, reinvasion by termites appears not to occur as readily as it does by other soil and litter arthropods.

Introduction

The diet of termites consists principally of cellulose obtained from living, dead but sound, or decomposed vegetation, humus or soil, or various combinations of the above (Wood 1978). Although the wood of many species of plant may be eaten, there is generally considerable partitioning of the available food resource within any particular habitat. Species of *Coptotermes* and *Heterotermes*, for instance, are able to eat relatively undecayed wood with high levels of plant chemical defences, while others such as species of *Amitermes* eat more decayed wood, including humus (Wood 1978; Miller 1991). Certain native and exotic tree species may be preferred or avoided by the termites (French *et al.* 1981; Postle & Abbott 1991; Abensperg-Traun 1993; Abensperg-Traun *et al.* 1993). In Australia, the exotic pines *Pinus pinaster* and *P. radiata* have not been readily accepted by many termite species; notable exceptions are species of *Coptotermes* and *Heterotermes*, and the tropical *Mastotermes darwiniensis* (*e.g.* Gay 1957; Greaves 1959; Spragg & Paton 1980; Abensperg-Traun 1993). Replacement of native vegetation with pine plantations may thus be associated with a marked decline in termite diversity. No previous Australian studies have compared termite communities in native woodland with communities inhabiting pine plantations. The present study reports preliminary results of surveys on termite diversity in native *Banksia* woodland on the Bassendean sands of the Swan Coastal Plain, and on adjacent stands of 40 - 70 year-old maritime pine.

Methods

Study area

The study was conducted at the Gnangara Pine Plantation (31°45′S, 115°48′E), about 20 km north of Perth, Western Australia, where pine plantations abutt onto native *Banksia* woodland. The soils are Bassendean sands, described in detail by McArthur & Bettenay (1960). The area has a mediterranean climate with cool wet winters and hot dry summers, with a mean annual rainfall of 866 mm (Bureau of Meteorology, Perth).

Native vegetation on the Bassendean sands at Gnangara is mostly open *Banksia* woodland. *Melaleuca raphiophylla* (paperbark), *Nuytsia floribunda* (christmas tree), and species of *Allocasuarina* (she-oak) are also common. Eucalypts such as *Eucalyptus calophylla* (marri), *E. marginata* (jarrah), *E. todtiana* (coastal blackbutt) and *E. rudis* (flooded gum) are largely restricted to the swales between coastal dune systems. The shrubby understorey is diverse and consists predominantly of species of *Acacia, Xanthorrhoea, Hakea, Jacksonia, Melaleuca* and *Adenanthos* (Havel 1976; Heddle 1980).

For the establishment of pine plantations at Gnangara in the late 1920's and early 1930's, all banksias and eucalypts were clear-felled. The area was then burnt. Only logs of large trees survived the burn, and these were left on the ground. The area was then ploughed and pine seedlings were planted. Controlled burns in pine plantations at Gnangara are part of management strategy and usually follow thinning operations (C Sanders, CALM, *pers comm*).

Termite sampling

Termites were sampled opportunistically, using a spade and axe, by D H Perry from 1953 to 1966. The collections were made over an area of about 500 ha of *Banksia* woodland, and about 200 ha of two approximately 30 year-old pine stands (Wetherell Block). The pine stands replaced a *Banksia* woodland containing large eucalypts, and remnants of these were still present at sampling time. Termites were sampled in the soil, mounds (termitaria) and timber, and a list of all collected species was recorded. The pine plantations origi-

nally sampled for termites by D H Perry were again sampled in August and November 1994, allocating a total of approximately 4 man-hours to each of two study areas. Approximately 2 ha were sampled in each area. Specimens were identified to species following Perry *et al.* (1985). *Banksia* woodland was not sampled in 1994. We therefore assume that termite diversity in the *Banksia* woodland at the present time resembles that when sampled about 35 years ago, and that the early surveys remain a valid control to the 1994 data.

The first pine stand (Area 1; Compartment 15) was planted in 1930 and contained no large eucalypt trees prior to plantation establishment. It was clear-felled and replanted in 1962 following a fire. It had not been 'thinned' when sampled in 1994, with a dense stand of 15 - 20 m tall pines at 2 - 3 m intervals. Canopy cover was close to 100 %, and a 15 to 20 cm deep layer of pine needles covered the soil surface suggesting that the stand had not been burnt since it was planted. There was no understorey of native (or exotic) plants with the exception of a small number of *M. rhaphiophylla*. No remnants of *Banksia* stumps or roots were located, so termite sampling was restricted to the soil, and to standing and fallen dead pine.

The immediately adjacent pine stand (Area 2; Compartment 4) was planted in 1927. It supported *Banksia* as well as large jarrah and marri trees prior to the establishment of pines, and carried its first crop of approximately 30 m tall pines when sampled in 1994. The stand had been thinned to a density of approximately one tree at about 15 m intervals, giving a canopy cover of < 25 %. Although both areas had been under pine for over 60 years, they differed markedly as habitat for termites. In contrast to Area 1, Area 2 contained numerous remnants of eucalypt logs and stumps, and also regenerating balga (*Xanthorrhoea preissii*), paperbark (*M. raphiophylla*), jarrah (*E. marginata*) and marri (*E. calophylla*), which might provide foraging and nesting sites for termites. Low tree density and pine needle cover would facilitate higher levels of penetration of sun light, more closely resembling pre-plantation conditions.

Results and Discussion

The survey of *Banksia* woodland, about 35 years ago, identified 16 termite species from 10 genera (Table 1). Sampling within adjacent pine plantations identified only four species, three of which survived on a diet of pine (*Coptotermes acinaciformis raffrayi*, *C. michaelseni* and *H. platycephalus*); *Amitermes modicus* was recorded foraging on jarrah logs only.

In 1994, we recorded six species of termite in pine plantations, bringing the total termite diversity for pine plantations to 7 species (Table 1). In the unthinned stand, Area 1 which lacked remnants of eucalypt logs and stumps, we recorded only *Coptotermes michaelseni*. In the open, older stand, Area 2, we recorded two species of *Coptotermes* and one species of *Heterotermes* eating pine. *Hesperotermes infrequens*, *Amitermes conformis* and *Xylochonitermes occidualis* were recorded on remnant jarrah logs and stumps; *A. conformis* was also sampled within mounds of *C. a. raffrayi*. Stumps and fallen timber of *M. raphiophylla* did not support any termites. No termites were found inhabiting the top layer of the soil, despite the availability of a rich humus layer. The genera recorded in *Banksia* woodland but not in pine plantations are *Kalotermes*, *Microcerotermes*, *Nasutitermes*, *Occasitermes* and *Paracapritermes* (Table 1).

Table 1

Termite species recorded from native *Banksia* woodland at Gnangara on the Bassendean sands of the Swan Coastal Plain, and species recorded where *Banksia* had been removed and replaced with maritime pine (*Pinus pinaster*).

Termite species	*Banksia* woodland	Pine plantation		
	Sampled 1953 to 1966	Sampled 1953 to 1966	Sampled in 1994	
			Without *Eucalyptus*	With *Eucalyptus*
Kalotermitidae				
Kalotermes hilli	+			
Rhinotermitidae				
Coptotermes a. raffrayi	+	+		+
Coptotermes michaelseni	+	+	+	+
Heterotermes occiduus	+			
Heterotermes platycephalus	+	+		+
Termitidae				
Amitermes conformis	+			+
Amitermes heteroguathus	+			
Amitermes modicus	+	+		
Amitermes sp.	+			
Hesperotermes infrequens	+			+
Microcerotermes newmani	+			
Nasutitermes exitiosus	+			
Occasitermes occasus	+			
Paracapritermes kraepelinii	+			
Xylochomitermes occidualis	+			+
Xylochomitermes tomentosus	+			
Total number of species	**16**	**4**	**1**	**6**

Termite diversity in pine plantations may have been low compared to *Banksia* woodland because the area sampled for termites, and sampling effort, was greater for *Banksia* than for pine areas. However, we hypothesize that two factors may have contributed to the lower termite diversity of pine plantations; (1) replacement of palatable native woody plants with exotic, unpalatable species, and (2) modification of soil microclimatic conditions.

Chemical composition of the timber, and hence its palatability, is often of critical importance to foraging termites (Wood 1978; Wood & Johnson 1986). For example, *Nasutitermes exitiosus* does not appear to eat pine and this may be because essential oils in the timber contain chemicals which are an important constituent of the termites' alarm pheromone (Moore 1969). Consistent with our observations, termite attacks on pine baits in the central wheatbelt of Western Australia were also restricted to *Coptotermes* (1 species) and *Heterotermes* (1 species) despite the presence of a species-rich community of wood-eating termites (Abensperg-Traun 1993).

Studies in eastern Australia show a progressive decline of *Nasutitermes exitiosus* colonies under pine plantations. This has been attributed to lower soil temperatures due to excessive shade rather than lack of food because the durable logs and stumps of eucalypt timber

remained for many years (Ratcliffe *et al.* 1952; Gay 1957; Lee & Wood 1971). Our observations are consistent with these other studies.

Several studies have shown that the diversity of other soil and litter arthropods is markedly lower in pine compared to relatively undisturbed native vegetation on similar soils (Springett 1971, 1976; Majer 1978, 1985; Rossbach & Majer 1983). Some of these studies (*e.g.* Springett 1976) also indicate that with increasing age of the plantation, arthropod diversity also increases. Successful reinvasion by other arthropods may be influenced by a progressive decline in canopy and pine needle cover through logging and fire. Our observations suggest that the rate of reinvasion by termites may be slower compared to many other arthropods, and that the return of native trees for food may be an important factor influencing reinvasion by termites.

The observations reported here are clearly preliminary. However, given that about 70 000 ha are under pine plantations in south-west Western Australia (Abbott 1993), an experimental study into the long-term effects of pine plantations on termite diversity is warranted.

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